REMARKS

Applicants request reconsideration of the above-identified application in light of the amendments and remarks described herein. Claims 1, 3-8, 11-22, 24-26, and 28-38 were pending in this application. Claim 16 has been canceled, Claims 1, 15, 17, 24-26, and 28 have been amended, and new Claim 39 has been added. Thus, Claims 1, 3-8, 11-15, 17-22, 24-26, and 28-39 are now pending in this application.

Claims 1, 3-8, 11-22, 24-26, and 28-38 have been rejected. In that regard, all of the pending claims have been rejected under 35 U.S.C. § 103(a). Applicants respectfully submit that all claims are now in condition for allowance. Accordingly, applicants request reconsideration and allowance of all claims.

Background

A conventional electrodeposited copper film is presented in FIGURE 2 of the application. When using organic additives, such as accelerator agents, to preferentially fill recessed microstructures, a phenomenon is exhibited in which deposited metal overfills the recessed microstructure, forming an overburden of metal above the recessed features. This phenomenon has been referred to as the "momentum plating" effect. As seen in FIGURE 2, overburden "bumps" on the top of the feature can be observed. Bump heights are strongly dependent on the feature size and feature density, with large bumps on top of the small, dense features. Since the conventional next step after electroplating is the use of a chemical-mechanical polishing technique (CMP) to planarize the wafer surface, these pattern dependent bumps can lead to uniformity problems for the CMP process. CMP may differentially polish areas of the substrate due to the raised bumps, as further complicated by different grain structures for the bumps and surrounding areas.

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Brief Description of the Claimed Invention

The embodiments of the present invention are directed to processes and apparatuses for applying a forward plating power to cause metal ions to be deposited from the plating bath and/or anode onto the substrate, followed by applying a reverse plating power, at a level and for a sufficient second period of time, so as to limit the formation of an overburden plating bump over the recessed feature.

Dubin Fails To Teach or Suggest All of the Claim Limitations

Claims 1, 3-8, 11-15, 22, 24-26, and 28-31 have been rejected under 35 U.S.C. § 103(a) over U.S. Patent No. 5,972,192, issued to Dubin et al. (hereinafter "Dubin"). Applicants disagree.

As described in the previous response, independent Claims 1 and 24-26 are directed to a process for depositing a metal structure on a surface of a workpiece defining a plurality of recessed structures. Claim 28 is directed to an electroplating apparatus for applying a metal structure to a surface of a workpiece defining a plurality of recessed microstructures. All of these claims generally recite limitations directed to process steps or structure for supplying reverse electroplating power between the anode and the surface of the workpiece during at least a portion of a second time period to limit the deposition of further copper ions over the at least partially filled recessed microstructures relative to the remainder of the surface, wherein the second time period is "greater than or equal to ten seconds." Claims 1, 24-26, and 28 have been amended herein to further recite an electroplating bath including a source of metal ions and "an accelerator agent," as recited in previously-pending Claim 16, which has now been cancelled.

As is well known, to establish a *prima facie* case of obviousness, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine the reference

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teachings, there must be a reasonable expectation of success, and the prior art reference (or references when combined) must teach or suggest all of the claim limitations.

Dubin fails to teach or suggest all of the claim limitations of Claim 1, 24-26, and 28. First, Dubin fails to teach or suggest a second time period greater than or equal to ten seconds. The Office Action states that Dubin indicates that the kinetics of electroplating copper were observed after time periods of 20, 40, and 80 seconds in Example 1, and that all of these time periods are in the range of the second time period recited in Claims 1, 24-26, and 28 of the present application. However, applicants disagree with the logic of the Office Action because Example 1 is directed to supplying forward pulse plating (as described in subparagraphs (b) in Claims 1 and 24-26 and paragraph (d) in Claim 28 of the present application), and not to supplying reverse electroplating power. Therefore, the time periods of 20, 40, and 80 seconds recited in Example 1 of Dubin are not applicable to the second time period for supplying reverse electroplating power, as recited in the claims. These time periods are simply intermediate process points, at which Dubin describes evaluating the process results, or fill kinetics, and have no relation to processes or apparatuses for depositing copper for manufacturing semiconductor devices.

Second, Dubin fails to teach or suggest the addition of an accelerator agent. In that regard, Dubin merely teaches the addition of a leveling agent or a brightening agent (see, e.g., Column 3, lines 43-49), but not an accelerating agent.

For at least these reasons, applicants request withdrawal of the rejections of Claims 1, 24-26, and 28, and the claims depending therefrom, as obvious over Dubin.

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There Is No Suggestion or Motivation to Combine the Teachings of Dubin and Ueno

Claims 1, 3-8, 11-15, 22, 24-26, and 28-31, and 33-17 have been rejected under 35 U.S.C. § 103(a) over Dubin in view of U.S. Patent No. 6,245,676, issued to Ueno (hereinafter "Ueno"). Applicants disagree.

As described above, embodiments of the present invention are directed to processes and apparatuses for depositing a metal structure on a surface of a workpiece defining a plurality of recessed structures using an *accelerating agent*, as recited in Claims 1, 24-26, and 28. Positive current, or reverse electroplating power, is used in embodiments of the present invention to desorb the organic additives, or accelerating agents, from the deposited metal on the substrate to *limit* the deposition of momentum plating overburden bumps.

Ueno is relied upon in the Office Action to provide the teaching that is missing from Dubin, namely the limitation relating to the second time period being greater than or equal to ten seconds. The Office Action submits that the second time period of "greater than or equal to ten seconds," as recited in the claims of the present application, overlaps with the time period of "within about 10 seconds" disclosed in Ueno. Applicants disagree with the position taken in the Office Action. In addition, applicants submit that Ueno, like Dubin, also fails to teach or suggest the addition of an accelerator agent. In that regard, Ueno teaches the use of a *retarding agent*, not an accelerating agent.

More importantly, applicants submit that the references cannot be combined to arrive at the claims of the present application, because the suggested combination of references would change the basic principle under which Dubin was designed to operate. Specifically, Ueno teaches a wholly different process of electroplating copper interconnects using a plating current pattern and a *retarding agent* to control the copper plating. As described in Ueno, Column 9, lines 42-47, "a positive pulsed current is a back bias current to remove additive molecules that

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are adsorbed at a high current density portion, and hence the copper plated layer is more deposited at a high current density portion by conducting the positive pulsed current." As described in Ueno, by removing *retarding agent* additive molecules (which would suppress deposition) by conducting positive (or reverse) pulsed current, an increase in net deposition of copper is acheived. Therefore, Ueno teaches that a positive (or reverse) pulsed current is used to *increase* net deposition of copper, and not to limit the deposition of copper ions, as recited in the claims of the present application.

In contrast, Dubin teaches reducing copper deposition during a reverse pulse plating step, as described at Colum 7, lines 5-15:

> During the first electroplating phase, Cu or a Cu alloy is electroplated to a thickness of about 1/2 of the opening (contact, via or trench) width, employing DC, forward-reverse or forward pulse plating. During the second electro-etching phase, the thickness of deposited copper is reduced by anodic dissolution by employing anodic DC or pulse dissolution [e.g., reverse pulse or reverse-forward pulse] to have about the same or smaller Cu thickness at the corners of openings than that on the side walls. During the third electroplating step, cathodic current is employed (DC, forward pulse or forward-reverse pulse) to fill the openings.

Therefore, the suggested combination of Ueno with Dubin would change the basic principle under which Dubin was designed to operate, that is, using a reverse pulse plating step to *reduce* copper deposition, and not to *increase* net deposition of copper by supplying positive (or reverse) pulsed current. For at least this reason, there is no suggestion or motivation to combine Dubin and Ueno because the suggested combination of references would change the basic principle under which Dubin was designed to operate.

Moreover, applicants reiterate that Ueno teaches the formation of an overburden as desirable. As noted in Ueno at Column 8, lines 25-32, referring to Figures 1A-C and 2A, after trenches 14-1 to 14-n are filled, plating continues in order to purposefully produce an overburden above the filled trenches 14-1 through 14-n. *See also* Column 4, lines 14-21. According to

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Ueno, the formation of this overburden is desirable to avoid the undesirable dishing of the surface of the interlayer insulating film 12 illustrated in Figure 10 and described at Column 3, lines 31-44. Thus, Ueno teaches that it is desirable, not undesirable, to form an overburden over recessed microstructures.

While Sonnenberg and Cruetz are both cited in the Office Action as purportedly teaching the use of additives to improve copper deposits, both references still fail to cure the deficiencies of Dubin.

Because there is no suggestion or motivation to combine the teachings of Ueno with Dubin, and even if combined, Dubin and Ueno, either alone or in combination, fail to teach or suggest all of the claim limitations, applicants submit that the claims are nonobvious. Accordingly, applicants respectfully request withdrawal of the rejections of Claims 1, 24-26, and 28, and the claims depending therefrom, as obvious over Dubin in view of Ueno.

Other Rejections

Claims 16-21 have been rejected under 35 U.S.C. § 103(a) over Dubin and further in view of U.S. Patent No. 5,223,118, issued to Sonnenberg et al. (hereinafter "Sonnenberg"), and U.S. Patent No. 3,770,598, issued to Creutz (herinafter "Cruetz"). In addition, Claims 16-21 have been rejected under 35 U.S.C. § 103(a) over Dubin and Ueno, and further in view of Sonnenberg and Creutz.

Claim 32 has been rejected under 35 U.S.C. § 103(a) over Dubin and further in view of U.S. Patent No. 5,969,422, issued to Ting et al. (hereinafter "Ting"). In addition, Claim 32 has been rejected under 35 U.S.C. § 103(a) over Dubin and Ueno, and further in view of Ting.

Claim 38 has been rejected under 35 U.S.C. § 103(a) over Dubin and further in view of U.S. Patent No. 6,251,251, issued to Uzoh et al. (hereinafter "Uzoh"). In addition, Claim 32 has been rejected under 35 U.S.C. § 103(a) over Dubin and Ueno, and further in view of Uzoh.

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None of these secondary and tertiary references cure the deficiencies of Dubin. Therefore, for at least the reasons described above, applicants respectfully request withdrawal of the rejections.

CONCLUSION

In view of the foregoing amendments and remarks, applicants respectfully submit that the present application is in condition for allowance. The Examiner is invited to contact the undersigned with any remaining questions or concerns.

Respectfully submitted,

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